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(54) A PIPE SYSTEM OF HEAT INSULATED PIPES INCLUDING MEANS FOR DETECTING THE PRESENCE OF MOISTURE

(71) We, A/S E. RASMUSSEN, Kongensgade 107, Fredericia, Denmark, a company organised under the laws of Denmark, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statment:—

The present invention relates to a pipe system of heat insulated pipes including means for detecting the presence of moisture adjacent the exterior side of tubes which may form part of a subterranean district heating system. Normally, in systems of this kind, the tubes are constituted by iron tubes enclosed in a suitable insulating material, which may be moulded out in situ or be provided as a prefabricated insulation around the single tube lengths. In these prefabricated pipes the insulating material, e.g. polyurethane foam is again enclosed in an outer protective tube such as a plastic tube which serves to prevent intrusion of moisture into the insulating material. At the joints between the single pipe lengths, as well as at T-junctions in continuous pipes, the conductor tubes are welded together, sufficient welding space being provided by letting the conductor tube ends project from the ends of the other parts of the pipes; when the joints have been pressure tested the exposed parts of the conductor tubes are covered in suitable manner, preferably by mounting an outer tube casing around the joints, whereby these casings will bridge the space between the adjacent ends of the exterior protective tubes, whereafter the annular space between the conductor tube and the casing is filled with a suitable insulating material through a hole in the casing.

It is extremely important that the pipe system is overall protected against intrusion of moisture into the insulating material since moisture will not only make the insulation less effective, but also during the years cause corrosion attacks on the conductor tubes. The prefabricated tubes are moisture-tight due to the said protective plastic tube, but it has been experienced that the said tube casings at the joints may cause troubles in this respect, so no matter how tight the joints are supposed to be there will still be a certain possibility that a few of them are not or will not remain absolutely tight. Leakage in the system due to corrosion on the iron tube, can be extremely difficult to localise because the leak water may run a long distance inside the plastic tubes and thereby damage the insulation and disclose itself at a point far from the leakage point.

It is the purpose of the invention to provide a method for detecting leakage in the entire system or at least particularly sensitive parts thereof in such a manner that the presence of moisture adjacent the iron tube may be registered as a warning for a possible corrosion attack on the tube.

According to the invention there is provided a pipe system of heat insulated pipes of the type comprising one or more conductor pipes surrounded by a heat insulating material which is again surrounded by an exterior protective tube characterized in that at least in pipe sections particularly exposed to possible moisture intrusion there is permanently mounted one or more electrical conductors extending along the pipes in the space between the exterior side of the conductor pipe or pipes, but spaced from this side or sides, and the interior side of the protective tube, said one or more conductors being in electrical contact with said conductor pipe or pipes and/or with each other through a hygroscopic material layer which has a high electrical resistivity in dry condition thereof and a lower electrical resistivity in wet condition, whereas at one or preferably more

points of the pipe system the said conductors are accessible for measurement of the resistivity.

The invention also provides a prefabricated heat insulated pipe length suitable for use as a section of the pipe system according to the immediately preceding paragraph in which the ends of the conductor pipe or pipes project from the corresponding ends of the surrounding heat insulating material and the protective tube, characterized in that said one or more electrical conductors are mounted along the conductor pipe or pipes spaced therefrom inside the protective tube, and that at their ends the electrical conductor or conductors project from the ends of the heat insulating material so as to be connectable with the corresponding conductors of the following pipe length.

In the following the invention is described in more detail with reference to the accompanying drawing in which:—

Fig. 1 is a perspective view of a section of a pipe system according to the invention,

Fig. 2 a corresponding view of a pipe joint,

Fig. 3 a diagram of a pipe system and its associated electrical circuit, and

Fig. 4 is a connection diagram for a tone generator used in the system shown in Fig. 3.

The system shown in Fig. 1 makes use of prefabricated insulated pipes, viz. pipes having an interior iron tube 2, an exterior protective mantel tube 4 of synthetic material such as polyethylene, and a resinous rigid foam heat insulating material 6 such as polyurethane foam filling out the annular space between the two tube members. Where the pipes are joined or branched off the conductor tubes 2 are exposed as shown so that there is space for welding the iron tubes. When the joints have been pressure tested tube casings 8 are mounted across the joints, and care is taken that the connection between the casings 8 and the plastic tubes 4 are made very tight. Preferably, after the mounting of the casing the annular space between the casing and the tube 2 is filled with an insulating material poured down through a hole in the casing so that the joints themselves are insulated.

The pipes shown are of known construction with the exception that they are provided with an electric conductor 10 extending along the iron tube through the foam material 6 which serves to hold the conductor somewhat spaced from the iron tube. At the joints the conductors 10 of the different tubes are interconnected and held in such a manner that they do not touch the iron tube. At more places in the system, preferably at branchings in inspection wells, the conductors 10 are connected through wires 12 to easily accessible measuring terminals 13. In these terminals all conductors 10, 12 are interconnected, but it is possible to disconnect any of the wires 12 therefrom.

Since the conductor system 10 is overall electrically insulated from the tubes 2 there should normally be no electrical conductivity between the system of conductors 10 and the system of tubes 2; this can be tested in simple manner from a central point by means of a measuring instrument 14 interposed between the two systems in series with a voltage source as shown in the left-hand side of Fig. 1. If by this measurment a certain conductivity between the two systems is registered it can be counted that a moisture intrusion has taken place somewhere in the system, whereby a corrosion attack on the iron tube may start at that place. The measurement will say nothing about the location of the defect, but it is possible to encircle the defect by carrying out separate control measurements of the conductivity in restricted sections of the system, whereby the single connection wires 12 are used for this purpose, each pipe length being controlled by a measurement between the wires 12 at the ends thereof, these wires being disconnected from the terminals 13. When the defect has thus been localised to a certain pipe length it will be possible to determine the location in more detailed manner by carrying out a comparative resistance measurement between the tube 2 and the conductor 10 as measured from both ends of the pipe length, according to known measuring principles for the localising of short circuits in electrical cables.

In order to secure a correct positioning of the conductor 10 across the joints it is preferred as shown in Fig. 2 to wrap a felt layer around the exposed iron tube 2, whereafter the conductor 10 is placed along an exterior surface portion of this layer; thereafter another felt layer 18 is wrapped around the first layer so that the conductor 10 will be safely held between these two layers without being able to touch the iron tube 2. When the tube casing 8 has been mounted around the joint the remaining interior space may be filled with insulating material as described above. The interior layer 16 is hygroscopic and under dry conditions electrical insulating.

In the pipes of the system described below there is incorporated a second electrical conductor which in Fig. 2 is designated 20. This conductor is positioned along the exterior surface of the outer felt layer 18 so that it is held spaced from the conductor 10 also across the joints. In the said inspection wells both conductors 10 and 20 are led out through the casings 8 so as to be available for interconnection in the manner described below.

It will be understood that the conductivity measurement for registering a possible moistured part of the insulating material may be carried out between the conductors 10 and

20 instead of between the iron tube and one of the conductors.

The detailed localisation of the a possible defect may be done in the most accurate manner if the conductor 10 consists of an electrically conducting resistance material such as constantan; this, however, would be advantageous for detection of the conductivity in the entire system, due to the considerable electrical resistance to the remote portions of the conductors, and it may be preferable therefore to work with both a conductor of a relatively high resistivity and a conductor with low resistivity, i.e. in Fig. 2 the conductor 10 may represent a constantan wire whilst the conductor 20 is a copper wire. The central detection and the subsequent encircling of a possible defect may then be carried out with the copper wire as measuring conductor, whilst the detailed localisation of the defect may be carried out by means of the constantan wire along the specific section in which the defect is present; the constantan wire is better suited to give a reliable and exact result of the said comparative resistance measurement.

The constantan wire alone might theoretically be used for both the general detection and the detailed localisation of a defect. This is achieved, when low resistance conductors are connected to the ends of the constantan wires and connected back to the central measuring station. That is to say, all the terminals 13 are positioned in the measuring stataion and connected to the terminal wires 12 by means of copper wires. The measurements in the field for general detection and thereafter detailed localisation of the defect is then carried out from the central measuring station. In a large pipe system, it is almost impossible to work with so many exterior connections between the terminal points and the central measuring station.

As known from the art of telecommunication it is possible, however, to substitute a great number of conductors by a single or very few conductors when the electrical signals to be transmitted through the large number of conductors are transformed to alternating currents or voltages with mutually different frequencies, whereas for the detecting of the signals there is used a corresponding number of receivers which are each tuned according to one of the actual frequencies. With the use of this principle it is possible to place electrical oscillators such as tone generators working at mutually different frequencies in different junctions in the system. Thereafter, using one of the several suitable techniques, the performance of these generators is controlled according to whether a measuring wire connected to the generator is short circuited by another conductor with another voltage. That is to say, for example, whether there is increased conductance between the iron tube 2 and the wire 10. The measuring wire for each single generator may control an individual limited portion of the entire pipe system, i.e. the total length of the measuring wire may be so short that the wire may well be constituted by a resistive conductor such as a constantan wire, whereby this wire is also usable for the said detailed localisation of a possible defect. The other conductor 20 in the system which is of high conductivity may be used partly for the power supply to all generators and partly for constituting the said common conductor for leading the output signals from all generators to the central measuring position.

For persons skilled in the art it will be obvious that each of the tone generators may be connected to the measuring conductors such as the conductor 10 and the tube 2 in such a manner that an increased conductivity therebetween will cause a change in the frequency or intensity of the output signal from the generator. However, a frequency change might give rise to a faulty detection, and relative changes in the signal intensities would hardly constitute a good base for the measurements in a large network. According to the invention, therefore, it is preferred to let the tone generators be connected in such a manner that their power supply is short circuited in case of a shirt circuit between the measuring wires, whereby the output signal in case of a defect will completely disappear; this change is easy to detect in doubtless manner in the central measuring station.

The system illustrated in Fig. 3 makes use of this priciple, the tone generators designated 22 being connected in the system as shown in more detail in Fig. 4. The thick full lines 2 in Fig. 3 represent the iron tubes in a part of a district heating system in which the hot water is lead in and out as indicated by arrows in the left-hand side of the figure. The individual double pipe sections in the system between the different junctions and bends are designated a to m. The sections c, e, h, j, and l are connected to individual heat installations 24 in the output of a heating system. In the system there is used the tubes shown in Fig. 2, and the constantan wire 10 is represented by a dotted line at one side of the tubes. In the different junctions there is established such interconnections between the wires as are clearly illustrated in Fig. 3.

Each tone generator 22 comprises an oscillator element 26, see Fig. 4, an output circuit 28, and a power supply circuit 30. The output circuit 28 is connected in series in one of the copper wires 20, this wire being connected to a negative potential relatively to a positive voltage of e.g. 50 V supplied directly to the iron tubes 2. The positive voltage for the power supply of the generators is for each generator provided by means of a direct connection 32 to one of the tubes 2 in the junc-

tion, at which the particular generator is housed in an inspection well. The negative voltage for the power supply is supplied by means of a connection 34 to the constantan wire 10, which extends in a loop the other end of which is connected to the negative conductor 20 through a drop resistance 38. The output circuit 28 of all generators 22 are connected in series in the copper wire 20, whereby in the sections c, e, h, j, and l none of the copper wires are in use. The other end of this series connection is connected to the positive terminal of the voltage source through a condenser 40 so that the output signals from all generators are supplied to the terminals of the voltage source without any direct current occurring in the circuit whereby the copper wire 20 will have the negative voltage overall in the system so as to be able to supply negative voltage to all generators.

The constantan wires connected to the single generators form loops along different sections of the system; as appears from Fig. 3 the generator designated A will thus serve the sections a and b, generator B will serve the sections m and l, the generator C will serve the sections c, d and e, generator D will serve the sections f, g, and h, whilst generator E will serve the sections i, j, and K, the constantan wires along the different sections being connected in series and being electrically disconnected from the constantan wires in the other sections of the system.

As long as there is no electrical conductivity between the constantan wires 10 in the loops and the conductor tubes 2 the oscillator elements 26 will get the necessary power supply through the resistor 38 and the wires 36, 10, 34. If moisture enters the system at a certain point there will be a degree of short circuiting between the positive tubes 2 and the negative constantan loop which covers the particular point, whereby the supply voltage to the supply circuit 30 will be reduced until is no longer sufficient to operate the generator. The measuring receiver which is tuned to receive the output signal from the stopped generator will thus register the failing output signal and thereby clearly indicate the presence of a defect in the corresponding section of the pipe system. Since the particular section is automatically identified by the said receiver it is thereafter sufficient to carry out the resistance measurement directly on that section of the system which is served by the constantan loop belonging to the stopped generator.

If a certain generator shall only serve one conductor tube 2 over a given length it is of course possible to use the copper wire in this length in series with the constantan wire in order to form the measuring loop.

Instead of continuous conductors embedded in the insulating material of the pipes, it is possible to use wire insulated by an exterior casing from which measuring wires extend into the insulating material 6 at suitable intervals along the particular section. It is also possible to use a measuring wire 10 of a material which will be rapidly corroded or dissolved by the introduction of moisture or water so as to be electrically broken, whereby the defect is detectable since the wire is no longer able to support a control current therethrough. Moreover, the portions of the wire 10 extending within the plastic tubes 4 may be substituted by a conductive coating of the interior sides of the plastic tubes.

By the mounting of the pipe system, it is almost unavoidable that a certain amount of moisture is enclosed within the tube casing 8, because the joining work is often carried out in humid surroundings. Since every effort is made to seal the tube casings moisture-tight to the exterior plastic tubes 4 this enclosed moisture will not be able to escape, and so it might give rise to a false detection of a defect. In order to rapidly obtain normal dry conditions in the system it is preferred, therefore, to mount a one-way valve 42, Fig. 2, in the wall of the each tube casing 8, these valves being adjusted so as to allow the said moisture to escape therethrough by the increased steam pressure which will occur when the hot water is sent through the tubes 2. It is not considered necessary to describe these valves in detail, since many known one-way valves will be directly usable for the purpose. For example the valves may be constructed according to the same principles as used in valves for bicycle tubes, i.e. provided with a stem having an outlet hole in the side thereof, the stem being surrounded by a piece of tube rubber, which enables an outlet from the valve but prevents introduction of air and moisture from outside to the said side hole.

WHAT WE CLAIM IS:—

1. A pipe system of heat insulated pipes of the type comprising one or more conductor pipes surrounded by a heat insulating material which is again surrounded by an exterior protective tube characterized in that at least in pipe sections particularly exposed to possible moisture intrusion there is permanently mounted one or more electrical conductors extending along the pipes in the space between the exterior side of the conductor pipe or pipes, but spaced from this side or sides, and the interior side of the protective tube, said one or more conductors being in electrical contact with said conductor pipe or pipes and/or with each other through a hygroscopic material layer which has a high electrical resistivity in dry condition thereof and a lower electrical resistivity in wet condition, whereas at one or preferably more points of the pipe system the said conductors are accessible for measurement of the resistivity.

2. A pipe system according to claim 1, in

which the said hygroscopic material layer is constituted by the said heat insulating material.

3. A pipe system according to claims 1 or 2, in which at least one electrical conductor is made of constantan.

4. A pipe system according to claim 1, comprising at selective places, electrical oscillators working on mutually different frequencies and being power supplied by means of conductors extending along the pipes, and conductors connecting the output terminals of the generators with a central measuring device comprising selective receiver means for each frequency, the oscillators being so adapted and connected with said conductors along individual sections of the pipe system that an electrical short circuit between the conductors causes a measureable change in the output signal of the generator associated with the particular section of the system.

5. A pipe system according to claim 4, in which the oscillators are connected in such a manner in the circuit that their power supply terminals are short circuited in case of short circuiting between the said conductors.

6. A prefrabricated heat insulated pipe length suitable for use as a section of the pipe system according to claim 1, in which the ends of the conductor pipe or pipes project from the corresponding ends of the surrounding hygroscopic heat insulating material and the protective tube, characterized in that said one or more electrical conductors are mounted along the conductor pipe or pipes spaced therefrom inside the protective tube, and that at their ends the electrical conductor or conductors project from the ends of the heat insulating material so as to be connectable with the corresponding conductors of the following pipe length.

7. A pipe length according to claim 6, in which the electrical conductor or conductors are directly embedded in and held by a rigid resinous foam material.

8. A pipe system substantially as herein described with reference to the accompanyig drawing.

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1311472 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

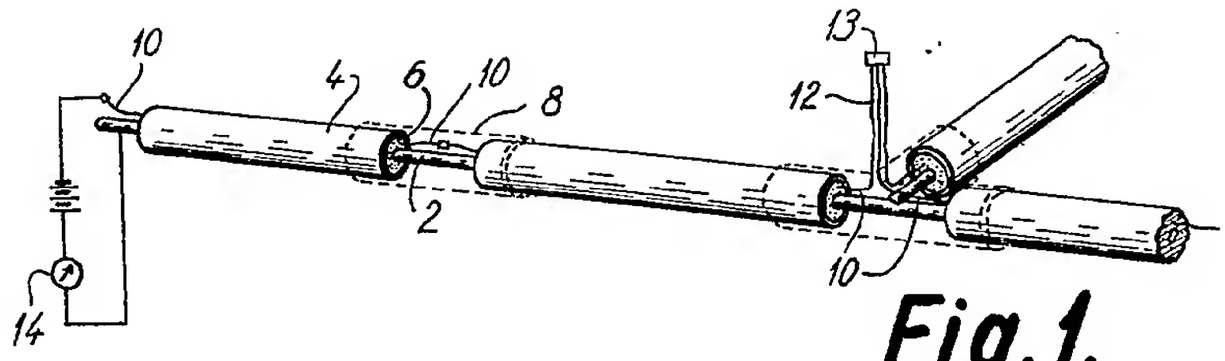

Fig. 1.

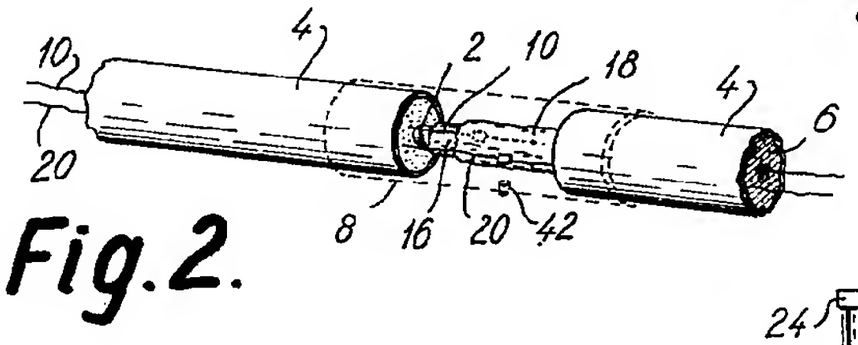

Fig. 2.

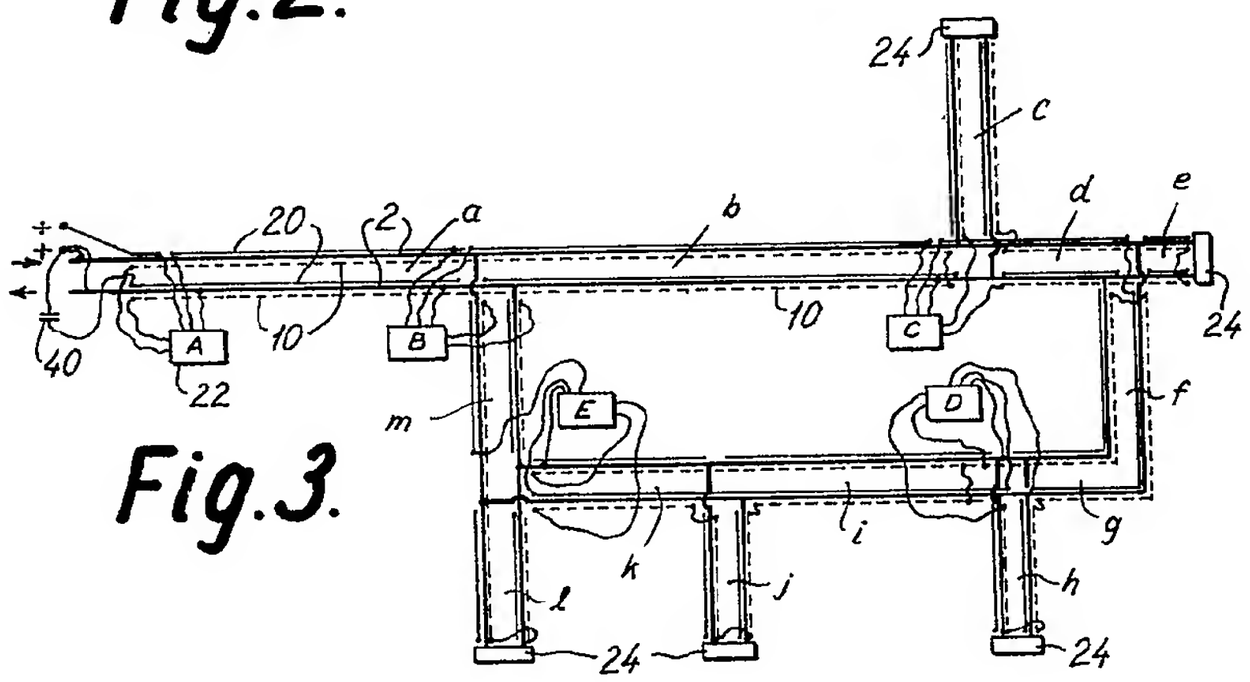

Fig. 3.

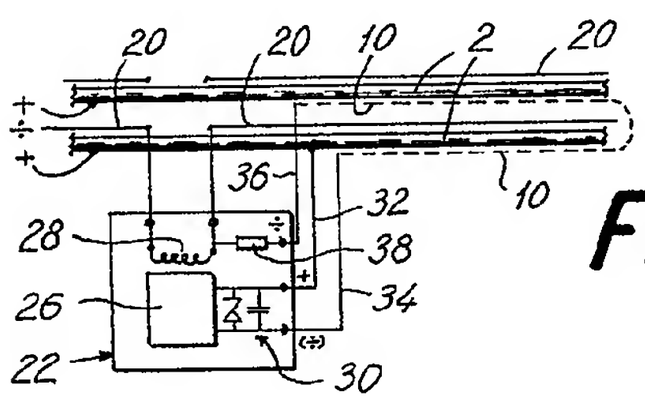

Fig. 4.